CHAPTER 5

CONTROL SYSTEM DRAWINGS

5-1 CONTROL SYSTEM DRAWINGS OVERVIEW

This chapter describes typical control system drawings and how to edit them to be project-specific. Chapter 6 'Project Implementation' provides an overview of the project-specific drawing requirements detailed in this chapter. The drawings are available from one of the following sources:

http://www.cecer.army.mil/KD/HVAC/
or
http://www.hnd.usace.army.mil/techinfo/ *(not yet available)*

The drawings were originally developed using AutoCAD® and every effort was made to ensure compliance with A/E/C CADD Standard Release 2.0. The drawings include metric and inch-pound layers. Additional drawing information is included in "DDC and UMCS Drawings User Guide" accessible at the above websites.

5-2 CONTRACT DRAWING SET

A set of Contract drawings will ordinarily consist of:

- Index (title sheet)
- Symbols and Legend drawing
- Points Schedule Instructions
- Scheduling Sequence
- Alarm Generator and Alarm Handling Sequence
- System specific drawing set

A system specific drawing set consists of (as applicable):

- Control Schematic
- Ladder Diagram
- Control Logic Diagram
- Sequence of Operation
- Points Schedule
- Other Schedules:
  - Thermostat and Occupancy Sensor Schedule
  - Occupancy Schedule
  - Redundant Alarm Handling Schedule
  - Control Damper Schedule
  - Control Valve Schedule

5-3 INDEX (TITLE SHEET)

The Index sheet lists drawings contained in the drawing set. Edit this sheet as required to make it project specific.

5-4 SYMBOLS AND LEGEND

The Symbols and Legend drawing shows the *Control Schematic Symbols*, *Control Logic Diagram Symbols*, and *Abbreviations and Acronyms*. Edit this sheet as required to make it project specific.

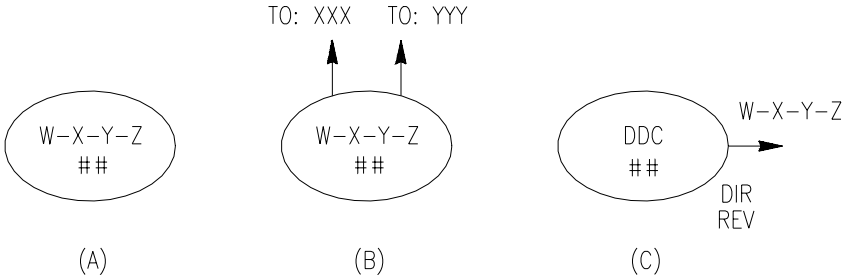
5-4.1 Symbols and Unique Identifiers

The control drawing symbols and identifiers adhere to a convention that is intended to uniquely identify each control system device and signal and to make interpretation of the control drawings as simple and as self-evident as possible. This includes the use of a defined set of symbols along with a naming convention for these symbols and their associated input and output signals. The naming convention includes the use of abbreviations and acronyms which are defined in the Appendix.

5-4.1.1 Symbols

Control schematic symbols: The generic symbol for a device used in a control schematic drawing is an ovular bubble as shown in Figure 5-1. Generic Device Symbols Devices can be shown with multiple input or output signals or additional I/O detail as shown in illustrations (B) and (C). The identifying letters and numbers associated with the symbols and associated signals are described in the paragraph entitled 'Unique identifiers'. Although not shown in Figure 5-1, most instrumentation symbol bubbles will show additional instrumentation detail such as a connected temperature probe or airflow measurement array. A complete set of control schematic symbols and their descriptions is located in the Appendix.

Figure 5-1. Generic Device Symbols



Control logic diagram symbols: There are a variety of symbols used to construct control logic diagrams. As is the case with control schematic symbols they have identifying letters and numbers associated with the symbols and input/output signals as described in the paragraph entitled 'Unique identifiers'. A complete set of control logic diagram symbols and their descriptions is located in the Appendix.

5-4.1.2 Unique identifiers

Devices symbols and their associated input/output signals use a naming convention, consisting of abbreviations and acronyms (W-X-Y-Z and ##), as shown in Figure 5-1, that describe the device or signal:

- **W** - Device descriptor; Describes the device, physical location of the device, source of the signal, destination of the signal, or the apparatus/function being controlled. In some cases a two-part device descriptor is used. For example MA-FLT is used to describe the mixed air filter.
- **X** - Measured variable or controlled device; In the case of a sensor or measurement instrument, it is temperature (T), relative humidity (RH), pressure (P), etc. In the case of an output it can describe the actuated device such as a valve (V) or damper (D).
- **Y** - Modifier; In some cases a modifier is required, such as indicating that a signal is a low-limit (LL) or high-limit (HL) input. Alternatively, the modifier may be used to describe the type of control signal such as a modulating command (C), start/stop (SS), enable (ENA), or disable (DIS) signal. Note that a signal can be a hardwired input or output to or from a device as shown in a control schematic or can be a logical constant or variable as shown in a control logic diagram.
- **Z** - In some cases an additional modifier is required, such as indicating that a signal is a setpoint (SP).
- ## - Device or signal number; When there are multiple identical control devices or signals, sequential numbering is used to avoid duplicate unique identifiers. All DDC controllers are numbered (by the contractor), even if there is only one, where the intent is to be able to show a single (common) DDC controller multiple times on a drawing. This can help to simplify the control drawings by showing fewer signal lines connected to a several DDC controllers instead of showing numerous signal lines connect to a single DDC controller. It also provides leeway to the contractor to use multiple controllers where project application requirements dictate the need. Device numbers are ordinarily assigned by the contractor based on project specific hardware application requirements as described in the Project Implementation chapter and as shown on the drawing notes.

Some example device symbol and signal names include:

- MA-T: Mixed air temperature
- MA-D-C: Mixed air damper command
- MA-T-LL: Mixed air temperature low limit
- MA-T-LL-SP: Mixed air temperature low limit setpoint
- ECO-ENA: Economizer enable
- ECO-HL-SP: Economizer high-limit setpoint
- ECO-LL-SP: Economizer low-limit setpoint
- SA-T: Supply air temperature
- SA-T-SP: Supply air temperature setpoint
- CLG-V-C: Cooling coil valve command
- SF-C: Supply fan command (modulating control signal)
- SF-SS: Supply fan start/stop
- SF-S: Supply fan status

A complete list of acronyms and abbreviations, used to uniquely name devices and signals, is located in the Appendix.

5-5 POINTS SCHEDULE INSTRUCTIONS AND POINTS SCHEDULE

5-5.1 Overview

The Points Schedule Instructions drawing describes Contractor requirements for control system implementation including how to use, complete, and submit the Points Schedule drawing.

The Points Schedule drawing conveys a great deal of information critical to the design, installation, and subsequent performance of the control system. It includes hardware input/output information, device ranges and settings, ANSI 709.1 communications protocol data, and information about data that is to be used at the operator workstation by the Monitoring and Control software.

5-5.2 UMCS Content on UFGS-15951 Point Schedules

Some columns in the Points Schedule (labeled “M&C”) pertain to functionality provided by the Monitoring and Control (M&C) Software specified in UFGS-13801. These columns include SNVT names that the building (15951) Contractor must provide for use by the UMCS. Then, as stated in the Points Schedule Instructions drawing, when the building control system is integrated into a UMCS, these columns tell the UMCS Contractor what functionality to configure at the M&C Software. As discussed in the *UFC 3-401-02 Project Implementation Summary*[JB1], if the building will be ‘stand-alone’ and M&C functionality is required at the building level (to be provided by the 15951 Contractor), certain requirements from UFGS-13801 must be added to the 15951 specification or an edited version of UFGS-13801 must be used in conjunction with the 15951 specification.

5-5.3 Responsibilities

The designer is responsible for the initial set of Points Schedule entries. The UFGS-15951 Contractor is responsible for the bulk of the entries and submits the Points Schedule as a Design Drawing for government approval, then finalizes it as an as-built submittal. The as-built is then used as a contract drawing for use by the UFGS-13801 Contractor. Contractor responsibilities are described in the specifications and in the Points Schedule drawing notes.

- Entries required of the **designer** are shown bracketed as: [___]
- Entries required of the **13801 Contractor** are shown bracketed as: / ___ /
- Entries required of the **15951 Contractor** are shown bracketed as: < ___ >
- Spaces where no entry is ordinarily required contains a tilde: “ ~ “ (equivalent to an “n/a” or null value)

Many designer or contractor entries have already been filled in on the sample drawings. In these cases, the value is a recommended value that must be verified or changed by

the appropriate party (as indicated by the bracket type). Brackets that do not contain values (ie [___], <___>, or /___/) indicate that an entry is required. When editing the Points Schedules, delete the brackets after verifying/providing the entry. Do not leave cells blank, instead show the tilde ("~") to indicate a null value or that no further entry is required.

5-5.4 **Points Schedule Description and Instructions**

Points Schedule columns and entries are described below, along with any designer responsibilities. Contractor responsibilities are described on the Points Schedule Instructions drawing.

5-5.4.1 **Header Information**

5-5.4.1.1 **DDC Hardware Identifier**

A unique identifier is used to identify the control hardware device on the Points Schedule, Control System Schematic and other drawings and helps to maintain consistency between drawings. Note that this DDC Hardware identifier is different than the NodeID and the Node field of the address, which are described below.

The contractor is required to provide this information.

5-5.4.1.2 **DDC Hardware Location**

The physical location of the DDC Hardware. The contractor is required to provide this information; minimally this is the room number the DDC Hardware is located in.

5-5.4.1.3 **Node Address**

The logical address of the node (DDC Hardware) on the network, which consists of three fields: domain, subnet, and node. The contractor is required to use the Domain and Subnet values specified in Section 15951 and to record the entire device address on the Points Schedule

5-5.4.1.4 **Node ID**

A unique 48-bit identifier assigned (at the factory) to each ANSI-709.1 device. Sometimes called the Neuron ID. The contractor is required to provide this information.

5-5.4.2 **Alarm Generator DDC Hardware Information Header**

This contains basic information (similar to the Header Information) for the DDC hardware performing the alarm generation.

5-5.4.3 **General Columns Description and Instructions**

5-5.4.3.1 **Function**

Basic description of the function performed by this group of points.

5-5.4.3.2 **Name**

This is the point name. The Section 15951 contractor will provide point names as needed (for those points not already named) using the points abbreviations. The Section 13801 contractor will use these point names on graphic displays.

5-5.4.3.3 **Description**

This is a summary description of the point.

5-5.4.3.4 **Setting**

This shows setpoints and settings related to each point. Show setpoints and settings as required. Typical values are shown in the typical drawings. Include the appropriate engineering units for entries in this column.

The Section 15951 contractor will use these settings when configuring devices and will show the setting used when one is not shown.

5-5.4.3.5 **Range**

Shows the range of values associated with the point. For example, it could be a zone temperature setpoint adjustment range, a sensor measurement range, occupancy values for an occupancy input, or the status of a safety. Edit this column as required, including the appropriate engineering units. In general, the following will need to be edited:

- Zone setpoints
- Switch settings
- Occupancy modes – ensure consistency with the sequence of operation or use "<__>" to indicate that the Section 15951 contractor must provide this information.

The Section 15951 contractor will use these ranges when configuring devices, and will document the ranges used for those that aren't shown. Note that the Contractor must select ranges to meet Section 15951.

5-5.4.3.6 **nci/CP Name**

The name of the network configuration input (nci) or configuration parameter (CP) for this setting as specified in Section 15951. The Contractor provides this information for programmable controllers or application specific controllers that don't have plugins.

5-5.4.3.7 **I/O Type**

Shows the input/output signal type (if any) associated with the point. Point types can be either hardware I/O or network variable points:

- Hardware I/O
    - Analog Input (AI)
    - Analog Output (AO)
    - Binary Input (BI)
    - Binary Output (BO))
- Network variable points:
    - Network Variable Input (NVI)
    - Network Variable Output (NVO)

The Contractor will document the I/O used in this column, including any network inputs and outputs used to chare information between DDC Hardware.

5-5.4.4 **LDP and M&C Display Columns**

5-5.4.4.1 **LDP View Req'd**

An *"**X**"* entry in this column indicates that the point is to be viewable from a Local Display Panel (LDP).

5-5.4.4.2 **M&C Disp Req'd**

An *"**X**"* entry in this column indicates that the point is to be displayed on a workstation via Monitoring and Control (M&C) software.

5-5.4.4.3 **M&C Trend Req'd**

An "**X**" entry in this column indicates that the point is to be trended by the Monitoring and Control (M&C) software.

The intent of showing that a point is to be trended is to require the Section 13801 (UMCS) Contractor to set up a trend for the indicated points. Note that points not marked with an "**X**" may still be trended at a future time.

5-5.4.4.4 **SNVT Type**

The Contractor will show the SNVT type for all network variables

5-5.4.5 **Overrides Columns**

5-5.4.5.1 **LDP Ovrd Req'd**

An "**X**" entry in this column indicates that the point can be overridden (adjusted) from a Local Display Panel (LDP). If this column contains an "**X**", the **LDP VIEW REQ'D** column for that point should also contain an "**X**". LDP Overrides should never be used in conjunction with M&C Overrides, and should be used sparingly in any case. In general, LDP Overrides will only be used for 'stand-alone' buildings, those without a UMCS. If the project calls for a 'stand-alone' building and also requires a great deal of override capability, serious consideration should be given to installing a 13801 UMCS. See the *UFC 3-401-02 Project Implementation Summary*[JB2] for more information.

5-5.4.5.2 **M&C Ovrd Req'd**

An "**X**" entry in this column indicates that the point can be overridden (adjusted) from an operator workstation. Place an X in this column for each point that requires an override capability from the M&C Software. Note that in general overrides should not be required for inputs (process variables) and should be limited to setpoints and outputs.

5-5.4.6 **Alarms Columns**

5-5.4.6.1 **Alarm Condition**

This column shows the conditions under which an alarm occurs. Show the alarm condition(s) for each point. Some alarms include time delays in the "NOTES" where the intent is to prevent nuisance alarms on equipment start up. Alarms may be handled by the UMCS and/or by building-level DDC Hardware. Refer to M&C ROUTING NAME and BLDG ROUTING REQ'D for description of these two alarm handling methods.

5-5.4.6.2 **Alarm Priority**

This column shows the priority for alarms as either Critical (CRIT) or Informational (INFO). As specified in UFGS-13801, critical alarms remain in alarm until acknowledged by an operator and the alarm condition no longer exists; informational alarms shall remain in alarm until the alarm condition no longer exists or until the alarm is acknowledged. Show the alarm priority for each alarm

5-5.4.6.3 **M&C Routing Name**

This column shows the alarm routing that is to be used for each alarm. The entry in this column corresponds to an Alarm Routing Group as shown on the Alarm Routing Schedule drawing. Show the alarm routing group that is to be used for this alarm. If there is an existing Alarm Routing Group Schedule drawing from a prior project at this installation then coordinate with the installation to select the M&C Routing Name from one of the Alarm Routing Groups on the existing schedule.

If an Alarm Routing Schedule drawing does not already exist, then do one of the following:

- Coordinate with the installation to create an Alarm Routing Contact Schedule and an Alarm Routing Group Schedule, and use the Alarm Routing Group Schedule to determine the M&C Routing Name. This is the preferred approach, and can be employed even if there is not an existing UMCS to perform alarm routing. In this case the Schedules will be available and the proper alarm routing already determined if/when the building is integrated into a UMCS.
- If there is no existing UMCS, leave the entries in this column in brackets indicating it is a future designer option ([___]) to be completed when the UMCS is designed/installed. The UMCS designer.

5-5.4.6.4 **Bldg Routing Req'd**

An X in this column indicates that the redundant alarm handling is required for this alarm. Redundant alarms are primarily used for (extremely) critical processes and are intended to be redundant with alarms sent to a UMCS such that in the event the UMCS is 'down' an alarm will still be sent.

Put an "X" in this column to require redundant alarm handling. Limit redundant alarm handling to alarms that are extremely critical (ie safety issues may exist if alarm is not received). For all alarms with an "X" in this columns include redundant alarm handling information on the Redundant Alarm Handling Schedule drawing.

5-5.5 **Points Schedule Application Notes**

These notes describe Points Schedule entries for specific rows shown in the Schedule.

5-5.5.1 **Analog and Binary Inputs**

Any analog input (AI) or binary input (BI) can be viewed from an LDP or displayed using M&C software at a workstation, but AI's and BI's should not overridden from an LDP or workstation. In the event an AI or BI must be overridden, such as during start-up testing, it can be overridden using a network configuration tool.

5-5.5.2 **System Reset Button (RST-BUT)**

The activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and the system RST-BUT as a binary input (BI) local to the DDC controller is pressed. Reset could also be performed from a workstation or local display panel (LDP) using a network variable input (NVI) SNVT.

It is recommended that you coordinate the decision on how to perform system reset with the local O&M staff. If System Reset is to be performed from a local push button, show "BI" under the I/O TYPE column and show a tilde in all other columns. If System Reset is to be performed from via a network variable from the M&C Software and/or an LDP, show an "X" in the M&C OVRD REQ'D column and/or the LDP OVRD REQ'D column. The possible combinations for the RST-BUT are summarized in Table 5-1

Table 5-1: System Reset Button Options and Point Schedule Entries

System Reset From	Entry in I/O column	Entry in M&C OVRD REQ'D Column	Entry in LDP OVRD REQ'D Column
Local Push-Button Only	BI	~	~
Local Push-Button or M&C Software	BI	X	~
Local Push-Button or LDP	BI	~	X
Local Push-Button, LDP or M&C Software	BI	X	X
M&C Software Only	~	X	~
LDP Only	~	~	X
LDP or M&C Software Only	~	X	X

In addition to showing the RST-BUT functionality in the Points Schedule, edit the Control Logic Diagram as required.

5-5.5.3 **System Occupancy (SYS-OCC)**

Most systems will obtain their occupancy mode command (OCC, UNOCC, Warm-up/Cool-down) from a System Scheduler. The occupancy mode for the system is overridden via an override input to the System Scheduler, not to the DDC Hardware performing the specific system sequence of operations, so the system should never have an 'X' in either the M&C or LDP Override columns. Systems that do not require scheduling will not have a SYS-OCC row shown on the Points Schedule. For example, many infrared heating systems operate according to a manual on/off or an occupancy sensor.

Show SYS-OCC (include this row) for any system that is to operate according to a schedule. Show Occupied, Unoccupied and WUCD (Warm-up/Cool-down) scheduling times (hours of operation) in the OCCUPANCY SCHEDULE Drawing.

5-5.5.4 **Zone Occupancy (ZN-OCC) and Effective Occupancy (EFF-OCC)**

The operational mode (occupied or unoccupied) of a piece of DDC Hardware used to provide environmental control of a space or zone can be dictated by either the System

Scheduler (SYS-OCC) or by a binary input (BI) occupancy signal from the zone (ZN-OCC). This BI occupancy signal (ZN-OCC) can be from either an occupancy sensor or from an (occupant accessible) push button.

The EFF-OCC signal is a network variable output (NVO) from the DDC Hardware (controller) which indicates the current operational mode for the system. This output is used for monitoring of the system and (for terminal units requiring air handler service) as an input to the System Scheduler to allow the System Scheduler to place the serving AHU into occupied mode.

If the design is to include either an occupancy sensor or occupancy pushbutton, include both the ZN-OCC and EFF-OCC rows in the Points Schedule. On the Occupancy Sensor Schedule show the quantity of ZN-OCC BI's required to cause the System Scheduler to turn on the AHU that serves these zones, where a minimum of two BI's are recommended to help minimize inadvertent starting of the AHU due to cleaning or security staff passing through after hours.

5-5.5.5 **LDP View and Override**

The designer may require that LDPs be installed in each mechanical room where the intent is to support air handlers and other primary equipment such as hydronic systems. The template Point Schedules for Terminal Units shows no LDP 'view' or 'override' capability in large part because these units include thermostats that ordinarily provide an adequate operator interface. The designer may choose to show LDP functionality.

5-5.5.6 **Minimum Outside Air Flow**

The minimum outside air flow is the quantity of outside air required for fresh air or for makeup. Show the minimum outside air flow setpoint (MINOA- F-SP) when the outside air flow quantity is controlled using DDC Hardware, an air flow measurement array, and a flow control damper. Otherwise (where there is no closed loop control, such as in a constant volume system), show the minimum OA flow quantity as "Minimum Outside Air Flow Setting". It does not have a point NAME because it is not an actual signal (not measured using an installed sensor).

Show the Minimum Outside Air Flow Setpoint (MINOA-F-SP) for systems that perform closed-loop control of the outside air flow, otherwise show Minimum Outside Air Flow Settings.

5-5.5.7 **PID Loop Settings**

The PID Loop Settings are all the settings required to configure PID control, including but not limited to the P, I and D gains, deadbands and reset schedules.

5-5.5.8 **Filters**

As described in the Sequence of Operation Designer Notes, delete the filter pressure high limit switches if/where they are not needed. When filter switches are used, show on the Points Schedule whether the filter status should be displayed at an LDP or UMCS, or if the filter should be routed as an Alarm.

5-5.5.9 **Other Points**

These are points which are not associated with a control loop and are therefore included for monitoring purposes only.

5-5.5.10 **Unit Status**

The Unit Status point indicates if the system is operating in heating/cooling mode. This status is used as a monitored point at the M&C Software and as a heating/cooling request to a chiller, boiler or heat exchanger. For systems other than heat exchangers, a network variable of type SNVT_HVAC_STATUS is used for this point and the range shown for this point applies to the MODE Field of the SNVT. For heat exchangers a network variable of type SNVT_SWITCH is used instead.

5-5.5.11 **Heating Request and Cooling Request**

DDC Hardware controlling chillers, boilers and heat exchangers receive Unit Status inputs from their serviced equipment in the form of heating/cooling requests. The Chiller, Boiler or Heat Exchanger System Enable schedule shows under what conditions the equipment will be enabled.